PHYTOTOXICOLOGY ASSESSMENT INVESTIGATION IN THE VICINITY OF WINDSOR CERAMIC TILE (1987) LTD., WINDSOR 1990

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Phytotoxicology Section
Air Resources Branch

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Background

At the request of the Ministry's District Officer in Windsor, the Phytotoxicology Section conducted a complaint investigation regarding vegetation injury on the property of Windsor Ceramic Tile and the immediate vicinity on 26 September 1989. The District Officer suspected that the vegetation injury observed on the property may have been caused by the emission of fluoride and/or other elements from the ceramic tile factory.

The 1989 investigation found severe foliar injury and defoliation on a group of Linden trees growing in small, elevated planter-boxes on company property. Other nearby Linden trees planted normally in the ground appeared healthy and free of injury symptoms. Similarly, no injury to vegetation was observed at other off-site locations close to the plant. Based on these observations, it appeared that only vegetation associated with the planter-boxes sustained injury.

Analytical results of injured Linden foliage collected from the planter-boxes indicated the presence of fluoride and sodium levels were in excess of Phytotoxicology Upper Limit of Normal (ULN) guidelines. Elevated concentrations of the two elements were also found to be present in planter-box soils.

In spite of the elevated fluoride and sodium concentrations found in the foliage and soils, the injury symptoms and defoliation were more typical of drought conditions than air pollution. Because the source of the elevated fluoride and sodium levels found in the planter boxes may have been the tile plant, the Ministry's Windsor office requested that a survey investigation of vegetation in the area be conducted in 1990.

1990 Phytotoxicology Surveillance Investigation

On 9 October 1990, Phytotoxicology investigators D. McLaughlin and G. Vasiloff visited the area and established a network of 14 survey sites in the vicinity of the tile plant. Dogwood was selected as the survey vegetation since only this species was present at all sites. The locations of the 14 survey sites in relation to the Windsor Ceramic Tile plant are shown in Figure 1.

During the course of the survey, dogwood foliage at each site was examined for evidence of air pollution injury. In spite of the symptoms of senescence present on most foliage, no visible air pollution injury symptoms were observed. Following the observational phase, triplicate samples of the examined dogwood foliage (collected from the side of the crown facing the tile plant) were obtained for chemical analysis. New vinyl gloves were worn by the investigators during the sampling process in order to avoid sample contamination.

Foliage samples were submitted to the Phytotoxicology laboratory to be processed unwashed according to standardized procedures. Completed samples were forwarded to the Ministry's Inorganic Trace Contaminants laboratory for analysis of total fluoride, boron, copper, nickel, lead, zinc, iron, manganese, aluminum, cadmium, cobalt, chromium, molybdenum, sodium, strontium and vanadium concentrations.

Chemical Analysis Results

Fluoride

Concentrations of 16 elements detected in the dogwood foliage collected at 14 survey sites in the vicinity of Windsor Ceramic Tile appear in Table 1. Phytotoxicology Upper Limit of Normal (ULN) guidelines for each element (where established) are shown at the base of the table. Concentrations that exceeded ULN guidelines, have been underlined. The rationale behind the derivation of the ULN guidelines is provided in the attached appendix.

Fluoride concentrations in excess of the 15 ppm ULN guideline for rural foliage were detected in foliage at 11 of the 14 survey sites. The highest concentration (65 ppm) was found at Site 30, located approximately 100 metres immediately north of the factory. Foliar fluoride concentrations declined with increased distance from Windsor Ceramic. For example, at Site 25, 50 metres southwest of the factory, a fluoride concentration of 35 ppm was detected. One hundred metres southwest of the factory, the concentration was 30 ppm at Site 26. At Site 27, 500 metres southwest of the factory, the fluoride concentration had dropped to 11 ppm.

Sodium

In the dogwood foliage, sodium concentrations in excess of the 50 ppm ULN guideline were detected at 9 of 14 sites. The highest sodium concentration (517 ppm) was found in the foliage at Site 29. At most sites close to the factory, sodium concentrations exceeded the ULN guideline, however, with increased distance from Windsor Ceramic, foliar sodium concentrations declined sharply.

In order to fully assess fluoride and sodium emissions from Windsor Ceramic, the influence of two other known sources of these elements should be considered. A fluoride source (Morterm) and a sodium source (The Canadian Salt Company) are located 1.3 km west and 1.3 km southwest, respectively, of Windsor Ceramic Tile (Figure 2).

Although only two survey sites (28 and 29) are situated between Windsor Ceramic and Morterm, concentrations of fluoride were more elevated near Windsor Ceramic (43 ppm at Site 28) and declined with distance toward Morterm (32 ppm at Site 29). This rapid reduction with

increasing distance from Windsor Ceramic was also evident in other directions. This information suggests that the Windsor Ceramic factory is the source of fluoride in the immediate area of the factory. Based on the data obtained from this survey, a computer-generated contour map (Surfer™) demonstrates the strong relationship between the proximity of elevated fluoride concentrations and the Windsor Ceramic factory (Figure 3).

Figure 2 shows that Windsor Ceramic is located approximately 1.3 km northeast of The Canadian Salt Company. Sodium emissions from the salt mine could travel in a northeasterly direction and impact the environment in the vicinity of Windsor Ceramic. However, sodium concentrations at the 3 sites along this radius (25, 26 & 27) declined sharply with distance away from Windsor Ceramic and toward The Canadian Salt Company. The computer-generated contour map of foliar sodium concentrations demonstrates a clear sodium gradient away from the tile factory (Figure 4).

Strontium

An unusually high average strontium concentration was detected in the initial analysis of dogwood foliage from Site 35. The laboratory repeated the analysis of each of the triplicate samples to determine the veracity of the initial findings. The second analysis validated concentrations between 2100 ppm and 2400 ppm in the samples. The average strontium concentration detected in the control foliage was 137 ppm.

Since concentrations of this element at other sites close to Windsor Ceramic were comparable to or lower than the control, current ambient emissions from the factory are not the source. The occurrence of strontium at such high concentrations is not natural. The source of the high strontium concentration in dogwood foliage at Site 25 is unknown, but is localized.

Other Elements

For the remaining elements, no pattern of deposition related to the Windsor Ceramic factory is apparent. In most cases, concentrations of the other elements detected in the dogwood foliage were similar to those found in the controls, and all were below ULN guidelines.

Conclusions

Based on chemical analysis of dogwood foliage collected in the vicinity of Windsor Ceramic Tile, the factory is a current, although minor source of fluoride and sodium. Fluoride concentrations were above the ULN rural guideline at 11 of 14 sites, and sodium exceeded the guideline at 9 locations. The area affected by emissions of the two elements, however, appears to be relatively small. Concentrations of both elements declined rapidly with increased distance from the ceramic factory. Current ambient emissions from Windsor Ceramic Tile were not high enough to injure vegetation in the vicinity of the factory.

Except for unusually high strontium concentrations at Site 35, concentrations of the other elements were similar to control values, and all were below ULN guidelines.

TABLE: 1 Concentrations of 16 Inorganic Elements in Surveillance Foliage Collected in the Vicinity of Windsor Ceramic Tile, Windsor - 1990

Survey Site Number	Vegetation Sampled	Distance & Direction from Windsor Ceramic Tile	Concentration (ppm - dry wt) F	B	Cu	Ni	Pb	Zn	Fe	Mn
25	Dogwood	50 m SW	35	38	3	<2	<2	21	105	20
26	Dogwood	100 m SW	30	48	4	<2	<2	27	133	38
27	Dogwood	500 m SW	11	52	5	<2	<2	24	106	23
28	Dogwood	100 m W	43	46	3	<2	<3	23	203	25
29	Dogwood	200 m W	32	45	<3	<2	<2	23	213	27
30	Dogwood	100 m N	65	49	4	<2	1	29	137	28
31	Dogwood	200 m N	30	41	<5	<2	<2	28	153	19
32	Dogwood	700 m N	21	44	<5	<2	<2	26	173	56
33	Dogwood	75 m E	31	60	<4	<2	<3	31	207	42
34	Dogwood	150 m E	19	36	4	<1	<3	30	120	50
35	Dogwood	200 m SE	19	30	<4	<2	<2	27	95	24
36	Dogwood	700 m SE	17	62	<4	<2	<2	27	143	22
37 (Control)	Dogwood	3200 km SE	9	41	4	<2	<2	22	109	45
38	Dogwood	1400 m NNE	12	47	<4	<2	<3	28	130	40
Phytotoxicology Upper Limit of Normal (ULN) Guidelines for rural foliage.			15	75	20	5	30	250	500	NE

Underlined values are in excess of their respective ULN guidelines.

Data are average of triplicate analysis.

cont'd....

TABLE: 1 (Cont'd)

Survey Site Number	Vegetation Sampled	Distance & Direction from Windsor Ceramic Tile	Concentration (ppm - dry wt) Al	Cd	Co	Cr	Mo	Na	Sr	V
25	Dogwood	50 m SW	35	<0.10	<0.2	<0.5	<0.6	172	120	<0.5
26	Dogwood	100 m SW	39	<0.11	<0.2	<0.5	<0.5	85	39	<0.5
27	Dogwood	500 m SW	24	<0.10	<0.2	<0.5	1.3	42	57	<0.5
28	Dogwood	100 m W	58	<0.10	<0.2	<0.6	<0.5	243	51	<0.5
29	Dogwood	200 m W	70	<0.10	<0.3	<0.6	<0.5	517	39	<0.5
30	Dogwood	100 m N	93	<0.10	<0.3	<0.5	<0.5	213	68	<0.5
31	Dogwood	200 m N	59	<0.10	<0.2	<0.5	<1.4	157	53	<0.5
32	Dogwood	700 m N	41	<0.10	<0.2	<0.5	<0.9	67	31	<0.5
33	Dogwood	75 m E	66	<0.13	<0.2	<0.5	<0.8	130	99	<0.5
34	Dogwood	150 m E	48	<0.10	<0.2	<0.5	<0.4	72	153	<0.5
35	Dogwood	200 m SE	46	<0.10	<0.4	<0.5	<1.0	31	2233	<0.5
36	Dogwood	700 m SE	40	<0.10	<0.2	<0.5	<1.0	29	50	<0.5
37 (Control)	Dogwood	3200 m SE	41	<0.10	<0.2	<0.5	<0.7	11	137	<0.5
38	Dogwood	1400 m NNE	35	<0.10	<0.2	<0.5	<0.4	31	110	<0.5
Phytotoxicology Upper Limit of Normal (ULN) Guidelines for rural foliage.			500	1	2	8	1.5	50	NE	5

Underlined values are in excess of their respective ULN guidelines.

Data are averages of triplicate analysis.

FIGURE: 1 Locations of Vegetation Surveillance Sites in the Vicinity of Windsor Ceramic Tile (1987) Ltd., Windsor - 1990.

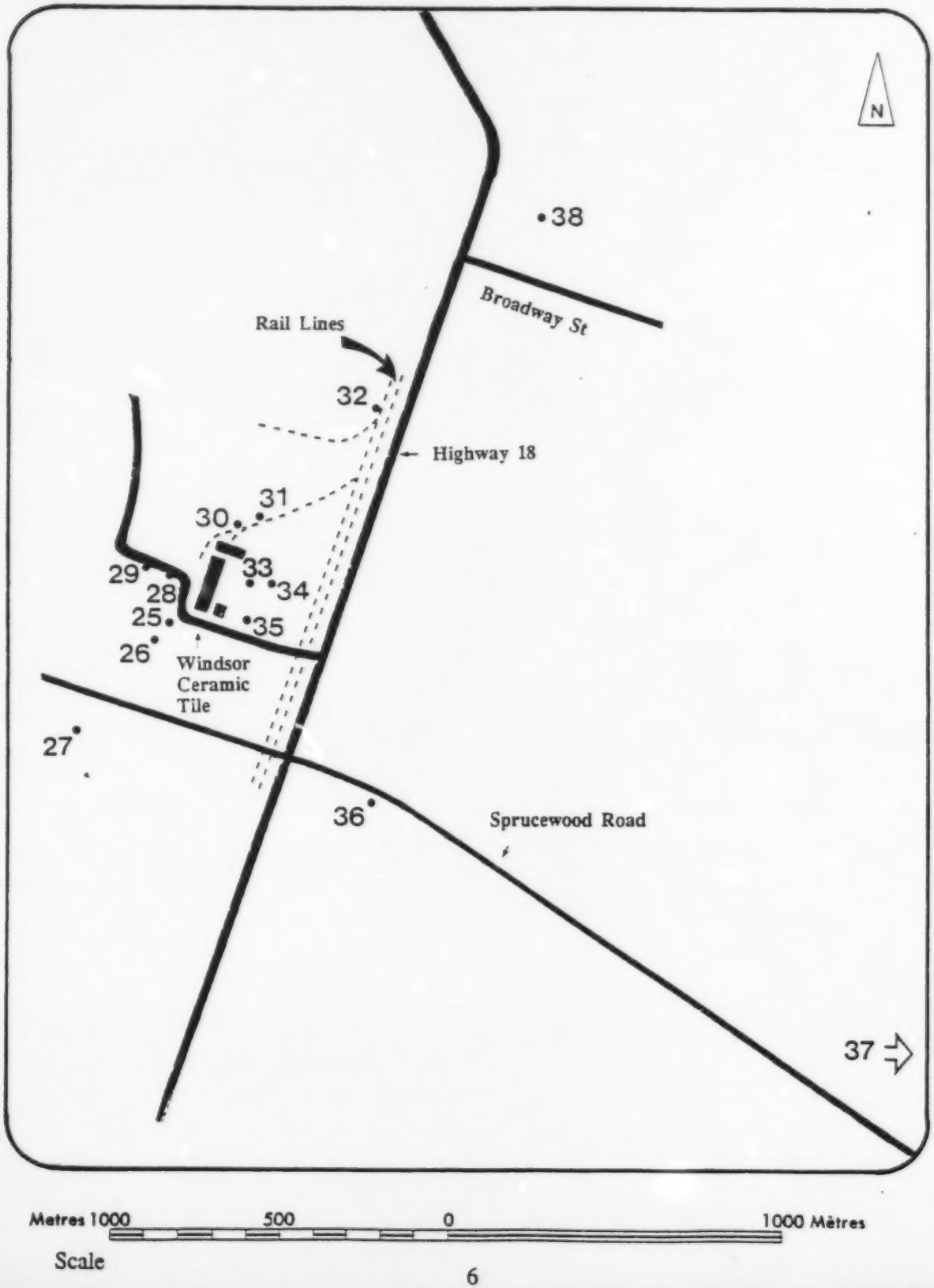


FIGURE: 2 Location of Windsor Ceramic Tile (1987) Ltd. in Relation to Morterm Limited and The Canadian Salt Company Limited.

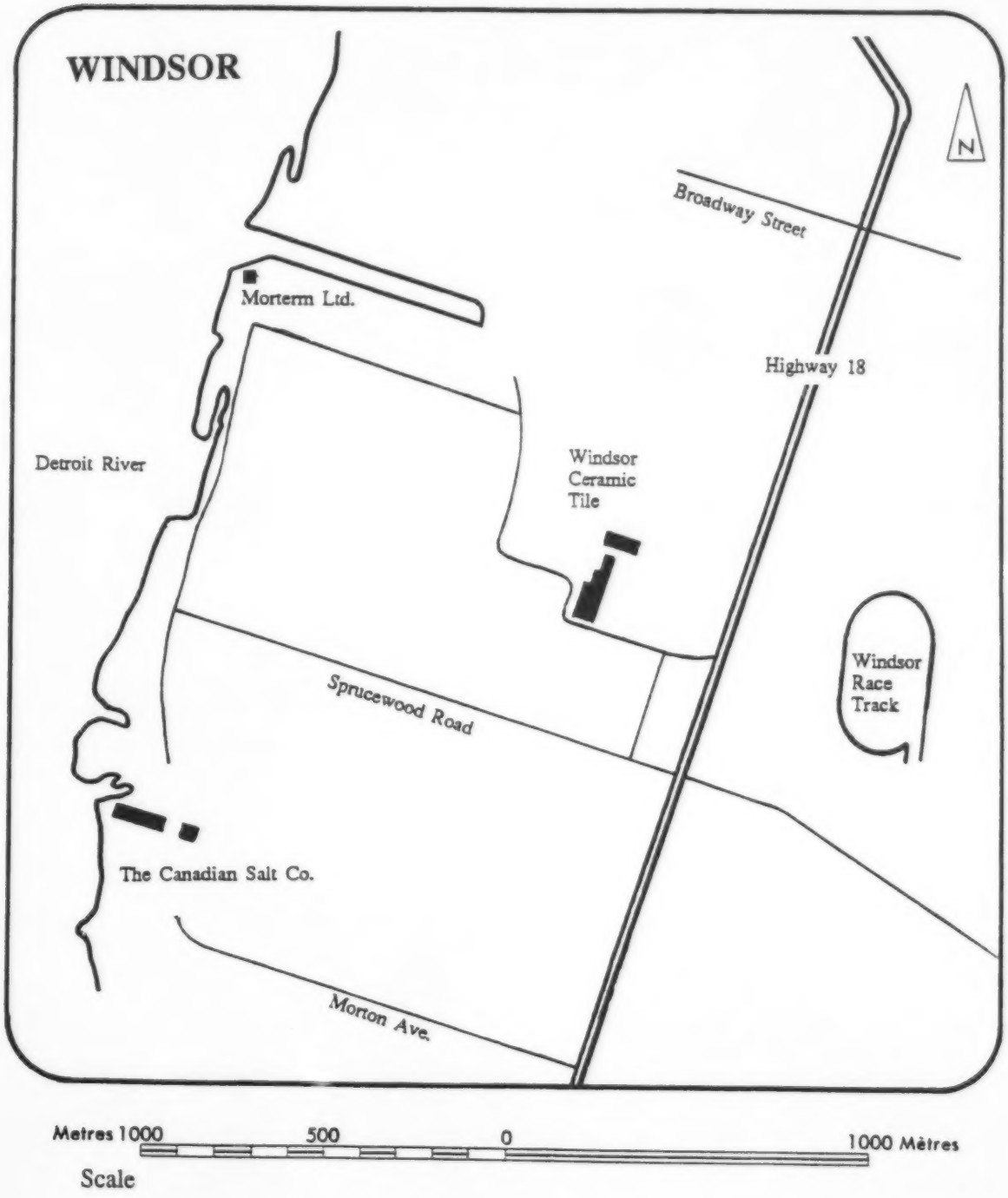
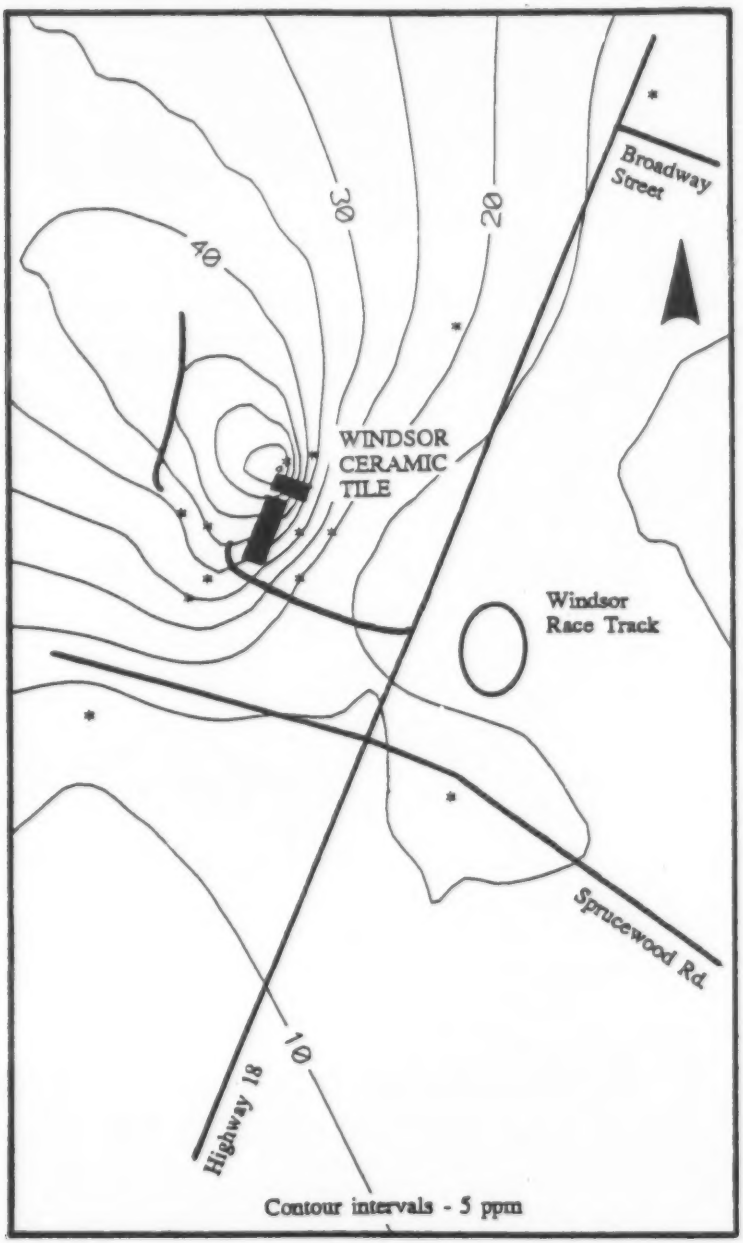
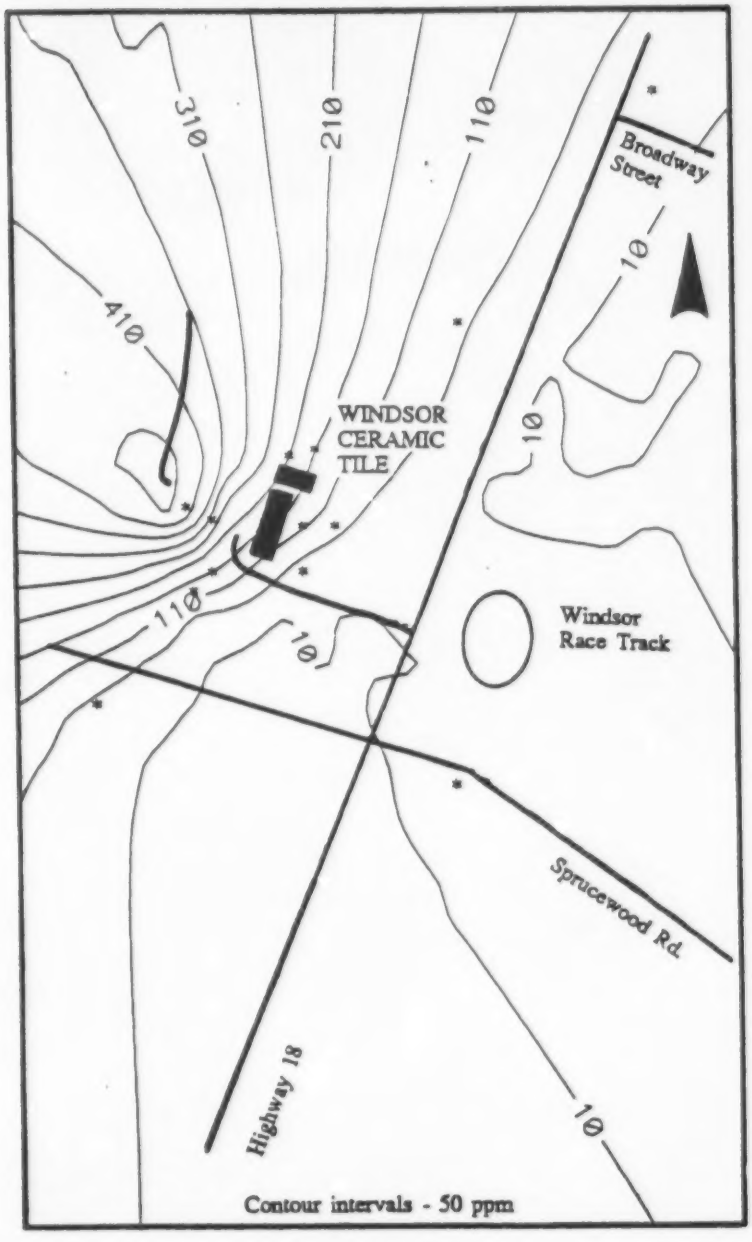


FIGURE: 3 Contour Map Showing Estimated Pattern of Fluoride in Dogwood Foliage in the Vicinity of Windsor Ceramic Tile (1987) Ltd., Windsor - 1990.



Map Not To Scale

FIGURE: 4 Contour Map Showing Estimated Pattern of Sodium in Dogwood Foliage in the Vicinity of Windsor Ceramic Tile (1987) Ltd., Windsor - 1990.



Map Not To Scale

APPENDIX

Derivation and Significance of MOE "Upper Limits of Normal" Contaminant Guidelines

The MOE "upper limits of normal" contaminant guidelines essentially represent the expected maximum concentration of contaminants in surface soil (non-agricultural), foliage (tree and shrub), grass, moss bags and/or snow from areas of Ontario not subject to the influence of point source emissions. "Urban" guidelines are based upon samples collected from centres of minimum 10,000 population. "Rural" guidelines are based upon samples collected by MOE personnel using standard sampling techniques (ref: Ministry of the Environment, 1983. Field Investigation Manual. Phytotoxicology Section - Air Resources Branch: Technical Support Sections - NE and NW Regions). Chemical analyses were performed by the MOE Laboratory Services Branch.

The guidelines were calculated by taking the arithmetic mean of available analytical data and adding three standard deviations of the mean. For those distributions that are "normal", 99% of all contaminant levels in samples from "background" locations (i.e. not affected by point sources nor agricultural activities) will lie below these upper limits of normal. For those distributions that are non-normsl, the calculated upper limits of normal will not actually equal the 99th percentile, but nevertheless they lie within the observed upper range of MOE results for Ontario samples.

It is stressed that these guidelines do not represent maximum desirable or allowable levels of contaminants. Rather, they serve as levels which, if exceeded, would prompt further investigation on a case by case basis to determine the significance, if any, of the above normal concentration(s). Concentrations which exceed the guidelines are not necessarily toxic to plants, animals or man. Concentrations which are below the guidelines are not known to be toxic.